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TECHNICAL NOTE

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EFFECTS AND OBSERVATIONS OF SOIL COMPACTION IN THE SALEM DISTRICT

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EFFECTS AND OBSERVATIONS OF SOIL COMPACTION IN THE SALEM DISTRICT

by

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Soil compaction and its effect on timber production is of increasing importance to forest land resource managers in view of national timber needs and environmental concerns. Managers need answers to questions relating to soil compaction influences on wood growth and the effects that timing and types of timber harvest methods have upon the soils so that long term productivity losses can be minimized.

Because only limited research information is available to guide decision makers, four field studies were made on past cutover areas in the Salem District to determine impacts that compaction has on timber production and the effects that different treatments have upon soil bulk density.

Case Study One

A study was made in a timber stand cut 55 years ago in Sec. 11, T. 10 S., R. 3 E., Linn County. Elevation of the study area is about 2,000 feet and annual precipitation ranges from 60 to 80 inches. The area has very dark brown loamy surface soils with a unified engineering classification of SM and dark brown clayey subsoils with a ML classification.

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The harvested timber was yarded to a railroad landing. Sample of bulk density and site index were taken in the railroad bed, the landing, and in an area distant to the landing that appeared to have no past disturbance (control). The results of this sampling is shown in Table 1.

TABLE 1 - The location, bulk density, and site index of 55-year old trees.

Location	Depth of Sample (Inches)	Bulk Density (gm/cc)	Site Index
Control	2-5	.70	160
	6-10	.70	
Landing	2-5	1.10	130
	6-10	1.04	
Railroad bed	2-5	.85	130
	6-10	1.00	

The site index data in Table 1 was determined by measuring the height, age and diameter of 5 well spaced dominant and co-dominant trees in the control, on the landing and in the railroad bed. If present growth rates of the control and compacted areas are projected to 80 years (allowable cut formula), using data in Table 1 and yield tables from, The Yield of Douglas-fir in the Pacific Northwest by Richard E. McArdle, then the compacted areas will show a 40% reduction of yield. Alder was the primary species observed growing on the railroad bed. Douglas-fir was the primary species adjacent to the railroad bed while roots of trees growing in the railroad bed were found to run along just beneath the ground surface and many roots were exposed to the air because they couldn't penetrate the compacted soil.

When roots reached the edge of the railroad bed, they turned down into the uncompacted soil.

Data in Table 1 shows that even after 55 years, bulk density in the compacted area is about 30% greater than the control.

Case Study Two

A second study was made in an area which had the timber cut and tractor yarded about 25 years ago in Sec. 35, T. 14 S., R. 7 W., Benton County. Elevation is about 1200 feet and annual precipitation ranges from 90 to 110 inches. The area has dark brown clayey surface soils with a unified engineering classification of ML and dark red clayey subsoils with a MH classification.

Bulk density samples were taken in the landing, in primary skid roads, and in an adjacent stocked area judged to be free of disturbance (control). These results are shown in Table 2.

TABLE 2 - Comparisons among bulk densities in an area compacted 25 years ago.

Location	Depth of Sample (Inches)	Bulk Density (gm/cc)
Control	2-5	.70
	6-10	.94
Landing	1-4	1.00
	5-8	1.55
	10-14	1.42
Skid road	2-5	.96
	7-10	1.36
Middle of skid road	7-10	1.26

Most of the compacted areas were nearly void of vegetation except for an occasional conifer, and some brush and grass. One 10-year old Douglas-fir tree growing in the landing was only 20 inches tall.

Roots were located mostly in the surface 4 inches while those below 4 inches penetrated fractures in the compacted area to a depth of about 10 inches. Adjacent trees, 20 to 30 feet in height, had roots growing right up to the compacted area then the roots would either parallel the edge of the compacted zones or would surface and occupy the surface 4 inches. No roots from the adjacent trees were found below 10 inches. Moisture content of the 10- to 17-inch compacted layer remained constant at 30 percent throughout the year. This indicated that no evaporation or transpiration had taken place from the compacted zone. Even after 25 years bulk density of soil in the compacted areas was considerably greater than that within the control area, Photo #1 depicts a compacted skid road.

Case Study Three

This study was made in an old growth timber stand in Sec. 13, T. 3 S., R. 8 W., Tillamook County that was partial cut 8 years ago with yarding done by tractor. Elevation is about 2000 feet and annual precipitation ranges from 100 to 130 inches. The area has very dark grayish-brown silt loam surface soils with a unified engineering classification of ML and dark yellowish-brown clayey subsoils with a MH classification. Bulk density and tree height measurements were taken in skid roads and in an undisturbed area (control). The results of these measurements are shown in Table 3.

Photograph # 1

Compacted Skid Road in a 25 year old stand of Douglas-fir. Note the absence of ground cover and erosion debris in left foreground.

TABLE 3 - Growth relationships of trees in bulk density.

Location	Depth of Sample (Inches)	Bulk Density (gm/cc)	Tree Measurements	
			Height (Feet)	Diameter (Inches)
Control	2-5	.66	15.0	3.0
	5-9	.62		
Skid road	2-5	.88 & .78	1.83	1.0*
	5-9	1.07 & .81		
Berms of skid road	2-5	.74	5.0	1.0
	5-9	1.00		

* Note: Ages of trees are 6 years.

Table 3 shows the growth relationship of trees is drastically less on the compacted areas than on the control area. Tree measurements represent the average of the height and diameter of two trees at each location. Very few trees were found in the skid roads even though a good seed source was nearby. One area in the skid road had soils that were mottled in the surface with gray colors, indicating that poor air and water transmission occurs. No mottles occurred in the control area indicating that water flowed freely through the soil instead of ponding. Even though bulk density measurements were below 1.10 very little rooting activity had begun in the compacted areas. This could be because roots will fully occupy the less compact surface soils before extending themselves into the more compact zones.

Case Study Four

A final study was made on a haul road in an area clear cut about 40 years ago in Sec. 31, T. 2 S., R. 7 E., Clackamas County. Elevation is about 1200 feet and annual precipitation ranges from 80 to 110 inches. The area has very dark brown sandy surface soils with a unified engineering classification of SP or SM and a yellowish-brown sandy subsoil with a SP or SM classification.

Bulk density measurements were taken on an old plank haul road, on a secondary haul road and on an area not occupied by haul roads (control). The results of these measurements are shown in Table 4.

TABLE 4 - Bulk density relationships to treatments in sandy soils.

Location	Depth of Sample (Inches)	Bulk Density (gm/cc)
Control	3-6	.72
	7-10	.80
	10-13	.68
Plank road	1-4	.54 *
	5-8	.63 *
	10-13	.90
Secondary haul road	2-5	.75
	6-9	.74

* The sample is high in organic matter which lowers the bulk density.

Numerous roots were found in the surface 8 inches at all locations. Many roots in the surface 4 inches were observed in roads and found going deeper into the subsoil at the edge of the road. Roots of trees adjacent to the road were found to grow right up to the road then grow parallel with the edge of the compacted zone or would surface and extend into the top 4 inches of the soil above the compacted zone. Smaller roots were observed growing into the soil area below 4 inches. Data in Table 4 shows that bulk densities are much higher in the 10- to 13-inch layer of the plank road than at the same level in the control. Observations revealed that compaction still existed after 40 years with no roots in the compacted layer. Successive observations in the secondary haul road and control indicated no evidence of compaction after 40 years. The primary species growing on haul roads was alder with Douglas-fir in the area adjacent to haul roads.

It appears that the entire soil in haul roads was compacted. Except for some compaction remaining in the plank road, the rest of the soils have recovered to their original bulk density.

Summary

Examples of soil compaction can be found in all parts of the District. These case studies illustrate the long term effects and the potential for serious yield losses than can occur from compaction. Observations of all types of timber harvest operations indicate compaction varies with yarding equipment used as shown in photo #2. Cable systems that drag the log, suspend the front end of the log or suspend the entire log reduce compaction, depth of compaction and area compacted with compactive effort inversely proportional to the amount of log suspension.

From observations, it appears that the major effect of compaction on tree growth occurs during the first 10 to 30 years. Photos #3 and #4 depict effects upon growth. Also compaction is not as persistent in sandy soils as it is in the finer textured soils. Compaction slows regeneration by reducing the size of the pore spaces in the soil which slows air and water transmission. Compaction also reduces the micro-relief that provides protection for seeds during germination. Compaction slows tree growth by restricting rooting only to the top few inches of the soil and

Photograph # 2

Extent of Areal Effect by Skid Roads

Skid roads constructed on steep ground. Note the deep excavations on the upper side of the skidroad which exposes large areas of soil parent material. The area occupied by the primary skid roads is approximately 15% as measured on aerial photographs.

Photograph # 3

Eight (8) year old Western Hemlock growing in uncompacted soil. Heighth of trees is 15 feet.

Photograph # 4

Eight (8) year old Douglas-fir tree growing in berm of skid road.
Heighth of tree is 5 feet.

growth is slowed until roots either penetrate the compacted layer or grow into the adjacent uncompacted layers. Although these studies represent a small sample of cutover lands there is sufficient evidence to believe that trees growing in compacted areas will never make up the growth loss caused by compaction. Furthermore, until the original low bulk density has been restored, the full productive capacity of the site will be reduced.

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